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Heavy metal migration and potential environmental risk assessment during the washing process of MSW incineration fly ash and molten slag

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Abstract

Based on the simulated moderate acid rainfall condition, MSW fly ash and molten slags were washed to investigate the effect of alkalinity on the migration and the speciation transformation of heavy metals in the approaching natural environment. All the samples were washed 150 min at 25℃ with the 100ul/min flow speed, then the after-washing samples were placed at air atmosphere for 60 days to get dried after-washing fly ash and molten slag samples. The total concentration of heavy metals in raw fly ash was followed by Zn>Pb>Cu>Cr>Cd>As>Ni, After washing process, the order is still the same, and the content of heavy metals in fly ash were significantly increased due to soluble salt leaching, especially Cr, Cu, Ni, Zn. The potential ecological risk (PEI) analysis, using STI toxicity model, indicated that PEI index of fly ash after washing was 2.3 times than that before washing. Therefore, it will cause greater ecological risk for the open storage of fly ash. When the fly ash was converted into molten slag, the alkalinity in the range between 0.8 and 1.2 was benefical for reducing PEI index of molten slags. The ash molten slag can be directly used as roadbed material due to the good solidification effect of heavy metals.

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Keywords: heavy metal, fly ash, washing, alkalinity, risk assessment

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1. Introduction

With the development of economic and urbanization, the increasing number of urban waste can be visibly seen, according to the basic requirements of sustainable development, waste incineration has a very bright future in various processing methods[1-3]. Incineration has gradually become a popular treatment of municipal solid waste in China for energy recovery and volume reduction, especially developed cities. Recently studies indicated that the amount of ash residues such as slag, bottom ash and fly ash accounted for 30wt% - 35wt% of total MSW incinerated. As a by-product, the incineration ash residues with large discharged amount are nowadays attracting more and more concern due to the significant concentration of heavy metals and toxic organic pollutants, especially fly ash[4-6]. In 2013, China's burning of garbage power plant reached 166, an amount of 46.337 million tons of garbage incineration, reaching 30.1% of the total capacity (The National Bureau of Statistics of China). And China's current waste incineration fly ash proper disposal is less than 10%. Fly ash can contaminate soil, groundwater and causes potential damage, especially in the state of rain shower, heavy metal transition to an unstable form, increasing the risk of contamination to the environment.

Most researches emphasized the the effect of water and acid solution washing municipal solid waste incineration fly ash, but few scholars have researched on the molten slag washing. In this study, heavy metals were extracted by BCR (Community Bureau of Reference) method in this forms: the acid-exchangeable (ACE), reducible (RED), oxidisable (OXI) and residual (RES) forms, and they were significant differences in thermal stability and the leaching[7]. The objective of this paper is to investigate the combined forms and redistribution of heavy metals under acid rain washing condition, and to evaluate their potential hazard to the surrounding environment.

The major research contents were as follows: (1) effect of alkalinity on ash melting temperature; (2) heavy metals partitioning in fly ash and molten slag after washing; (3) the potential risk toxicity in fly ash and molten slag.

2. Materials and method

2.1 Sample preparation

Raw municipal solid waste incineration fly ash (RA) was collected from the fabric filter in Shanghai, China. RA were grinded into powder samples with particle size < 75μm and dried for 24 hours in oven up to a constant weight, then, fly ash powder were put into dry glassware for next experiment. Analytic agent SiO_2 was added into fly ash powder to adjust the alkalinity of prepared fly ash powder. The alkalinity (mass ratio CaO/SiO_2, represented as AL) of 0.8, 1.0, 1.2, 1.6, 2.0 were named as A_1, A_2, A_3, A_4 and A_5, respectively. RA and SiO_2 were mixed together by ball mill for 30 min. Chemical compositions of RA were determined by XRF at air temperature. Chemical compositions of RA and prepared fly ash samples were shown in Table 1.

Table 1 Chemical components of fly ash samples

Chemical components	RA	Prepared fly ash samples				
		A_1	A_2	A_3	A_4	A_5
		AL_1=2.0	AL_2=1.6	AL_3=1.2	AL_4=1.0	AL_5=0.8
CaO	47.52	40.09	37.61	35.13	32.65	30.17
Al_2O_3	1.41	1.19	1.41	1.04	0.97	0.89
SiO_2	4.14	19.14	24.14	29.14	34.14	39.14
Na_2O	10.69	9.02	8.46	7.92	7.34	6.79
K_2O	7.81	6.59	6.18	5.78	5.37	4.96
Cl	17.67	14.91	13.98	13.06	12.14	11.22
SO_3	6.10	5.15	4.83	4.51	4.19	3.88
MgO	1.09	0.92	0.87	0.81	0.75	0.72
P_2O_5	0.91	0.76	0.71	0.66	0.61	0.57
Fe_2O_3	0.92	0.75	0.71	0.66	0.61	0.57
Others	1.76	1.49	1.39	1.31	1.21	1.12

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